Lingcod Egg Mass and Reef Fish Density SCUBA Survey in the Strait of Georgia, February 19 – March 11, 2005

D.R. Haggarty, J.R. King, and V.R. Hodes

Fisheries and Oceans Canada
Science Branch, Pacific Region
Pacific Biological Station
Nanaimo, British Columbia
V9T 6N7

2005

Canadian Data Report of Fisheries and Aquatic Sciences 1161

Pêches et Océans Canada | Fisheries and Oceans Canada

Canada

Canadian Data Report of
Fisheries and Aquatic Sciences

Data reports provide a medium for filing and archiving data compilations where little or no analysis is included. Such compilations commonly will have been prepared in support of other journal publications or reports. The subject matter of data reports reflects the broad interests and policies of the Department of Fisheries and Oceans, namely, fisheries and aquatic sciences.

Data reports are not intended for general distribution and the contents must not be referred to in other publications without prior written authorization from the issuing establishment. The correct citation appears above the abstract of each report. Data reports are abstracted in *Aquatic Sciences and Fisheries Abstracts* and indexed in the Department's annual index to scientific and technical publications.

Numbers 1 - 25 in this series were issued as Fisheries and Marine Service Data Records. Numbers 26 - 160 were issued as Department of Fisheries and the Environment, Fisheries and Marine Service Data Reports. The current series name was introduced with the publication of report number 161.

Data reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page. Out-of-stock reports will be supplied for a fee by commercial agents.

Rapport statistique canadien des
sciences halieutiques et aquatiques

Les rapports statistiques servent à classer et à archiver les compilations de données pour lesquelles il y a peu ou point d'analyse. Ces compilations auront d'ordinaire été préparées à l'appui d'autres publications ou rapports. Les sujets des rapports statistiques reflètent la vaste gamme des intérêts et des politiques du ministère des Pêches et des Océans, c'est-à-dire les sciences halieutiques et aquatiques.

Les rapports statisiques ne sont pas destinés à une vaste distribution et leur contenu ne doit pas être mentionné dans une publication sans autorisation écrite préalable de l'établissement auteur. Le titre exact paraît au-dessus du résumé de chaque rapport. Les rapports statisiques sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dans l'index annuel des publications scientifiques et techniques du Ministère.

Les numéros 1 à 25 de cette série ont été publiés à titre de relevés statistiques, Services des pêches et de la mer. Les numéros 26 à 160 ont été publiés à titre de rapports statistiques du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 161.

Les rapports statistiques sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

105-06889/

Canadian Data Report of

Fisheries and Aquatic Sciences 1161

2005

LINGCOD EGG MASS AND REEF FISH DENSITY SCUBA SURVEY IN THE STRAIT OF GEORGIA, FEBRUARY 19 – MARCH 11, 2005

D.R. Haggarty, J. R. King, and V.R. Hodes

Fisheries and Oceans Canada
Science Branch, Pacific Region
Pacific Biological Station
Nanaimo, British Columbia
V9T 6N7

©Her Majesty the Queen in Right of Canada, 2005

Cat. No. Fs 97-13/1161E ISSN 0706-6465

Haggarty, D.R., King, J.R., and Hodes, V.R. 2005. Lingcod egg mass and reef fish density SCUBA survey in the Strait of Georgia, February 19 – March 11, 2005. Can. Data Rep. Fish. Aquat. Sci. 1161: iv + 16 p.

ABSTRACT

Haggarty, D.R., King, J.R., and Hodes, V.R. 2005. Lingcod egg mass and reef fish density SCUBA survey in the Strait of Georgia, February 19 – March 11, 2005. Can. Data Rep. Fish. Aquat. Sci. 1161: iv + 16 p.

Dives were conducted at 4 sites in the Campbell River region of the Strait of Georgia and 2 sites in the Nanaimo region of the Strait of Georgia between February 19-March 11, 2005 to provide lingcod (*Ophiodon elongatus*) egg mass density estimates. The index site at Snake Island reef was included in this survey, and it has been previously surveyed in 1990, 1991, 1994, 2001, 2002 and 2004. We completed 5 dives at Maud Island, 5 at Copper Cliffs, 4 in Discovery Passage, 5 at April Point, 19 at Snake Island reef and 7 dives at Entrance Island. In addition to counting lingcod egg masses, large fish (>15 cm) were counted as well as juvenile rockfish (< 15 cm). Copper rockfish (*Sebastes caurinus*), lingcod, and kelp greenling (*Hexagrammos decagrammus*) were the most consistently encountered fish. Volunteer divers from the recreational dive community were recruited to conduct a portion of this survey.

RÉSUMÉ

Haggarty, D.R., King, J.R., and Hodes, V.R. 2005. Lingcod egg mass and reef fish density SCUBA survey in the Strait of Georgia, February 19 – March 11, 2005. Can. Data Rep. Fish. Aquat. Sci. 1161: iv + 16 p.

Des plongées ont été effectuées sur 4 sites dans la région de Campbell River et 2 sites dans la région de Nanaimo, dans le détroit de Georgia, entre le 19 février et le 11 mars 2005, afin d'obtenir des estimations de la masse des œufs des morues-lingues (*Ophiodon elongatus*). Le site repère de l'île Snake a été couvert lors du relevé. Il avait fait l'objet d'un relevé en 1990, 1991, 1994, 2001, 2002 et 2004. Nous avons effectué 5 plongées à l'île Maud, 5 aux falaises Copper Cliffs, 4 dans le passage Discovery, 5 à la pointe April, 19 aux récifs de l'île Snake et 7 à l'île Entrance. En plus de mesurer la masse d'œufs des morues-lingues, les chercheurs ont également compté les gros poissons (>15 cm) ainsi que les jeunes sébastes (< 15 cm). Les sébastes cuivrés (*Sebastes caurinus*), les morues-lingues et les sourcils de varech (*Hexagrammos decagrammus*) étaient les espèces les plus fréquemment rencontrées. Des plongeurs bénévoles, issus de la communauté des plongeurs récréatifs, ont été recrutés pour effectuer une partie de ces relevés.

INTRODUCTION

Lingcod (*Ophiodon elongatus*) have traditionally been a very important species in British Columbia's commercial fishery. Due to conservation concerns, the lingcod commercial fishery in the Strait of Georgia was closed in 1990 (Richards and Hand, 1989), and the recreational fishery was closed in 2002 (King, 2001). Egg mass density surveys were conducted at an index site, Snake Island reef (Statistical Area 17), in 1990, 1991, 1994, 2001, 2002 and 2004 (Yamanaka and Richards, 1995; King and Beaith, 2001; King and Winchell, 2002; King and Haggarty, 2004). A stock assessment framework for Strait of Georgia lingcod recommended that standardized egg mass density surveys be used to provide insight into relative abundance trends (King *et al.*, 2002). In 2004, additional sites were surveyed near Snake Island: Entrance Island, Round Island, Five Finger Island, Hudson Rock and Douglas Island. However, only Entrance Island had high estimates of lingcod egg masses (King and Haggarty, 2004). In 2005, we revisited both the index site at Snake Island and Entrance Island. In addition, four sites in the Campbell River region (Statistical Area 13) were selected for egg mass density surveys to augment the information obtained in Statistical Area 17. At these sites, we worked with recreational divers to asses the feasibility of using volunteer divers to conduct surveys similar to those conducted by DFO scientific staff.

There is also conservation concern regarding rockfish (*Sebastes* spp.) in the Strait of Georgia (Yamanaka and Lacko, 2001) and non-intrusive visual estimates of rockfish abundance may be required for species which are at extremely low abundance or for areas with depleted populations. We made visual estimates of rockfish densities at the 2005 SCUBA lingcod egg mass survey sites in order to provide information that might be used to develop a suite of non-intrusive surveys or used as auxiliary information to fishery and research surveys for rockfish.

METHODS

Six sites were selected for SCUBA surveys: Snake Island reef and Entrance Island in Nanaimo (Statistical Area 17); Discovery Passage, Maud Island, April Point, and Copper Cliffs in Campbell River (Statistical Area 13) (Figure 1). Snake Island reef is an index site for lingcod egg mass surveys and has been previously surveyed in 1990, 1991, 1994, 2001, 2002 and 2004 (Yamanaka and Richards, 1995; King and Beaith, 2001; King and Winchell, 2002; King and Haggarty, 2004). Entrance Island was also surveyed in 2004 (King and Haggarty, 2004). The sites in Campbell River were surveyed in a dive survey for reef fish abundance in October 2004. Depending on the weather, 1-7 dives were completed each day. Sampling began February 19, 2005, ended March 11, 2005, and occurred between the hours of 8:30 and 16:00 PST.

For the Campbell River sites, volunteer divers were recruited from the recreational dive community to conduct the survey. For each dive, two or three divers descended to <30 m (90ft) carrying a cannonball attached to the 10 m quadrat line. Once

at the bottom, the divers placed the cannonball in habitat suitable for lingcod nesting (assessed by the presence of crevices, rocks and boulders). The team of divers would then swim a circle, with a radius of 10 m, formed by the sweeping line, around the fixed point (cannonball) searching for lingcod egg masses and counting reef fishes. Once the circumference was complete, the divers would move the cannonball to the next quadrat center, ensuring that there was no overlap with the previous radius, and complete another quadrat. Even spatial coverage on the reef was achieved by dropping dive-teams in the water at different locations. While the selection of dive locations was not random, this method provided a trade off between maximizing dive time in habitat of interest to recreational divers but with some requirement for location selection based on habitat characteristics and not solely on presence of lingcod egg masses.

Dives at the Nanaimo sites, Snake Island Reef and Entrance Island, were conducted by Fisheries and Oceans Canada scientific staff. For each dive a surface deployed anchor buoy was released according to both a GPS position and a diveable depth (<20 m (60 ft)). We achieved even spatial coverage within a site and avoided overlap of surveyed areas (dives) by mapping the centre of each quadrat using the navigation program, Nobeltech©. Two divers descended from the marker buoy to the cannonball and then attached a 10 m line to the cannonball at the bottom of the marker buoy. The team of two divers would then follow the same circular sweep of the quadrat as the Campbell River procedure searching for lingcod egg masses and counting reef fishes.

Lingcod, rockfish (*Sebastes* spp.), greenlings (*Hexagrammos* spp.), cabezon (*Scorpaenichthys marmoratus*), and surfperches (Embiotocidae) were large (>15 cm) reef fishes that we expected to see on near shore reefs. Using a dive light, divers searched crevices and under large flora for these species. Total counts within the circular quadrat were recorded. Smaller fishes, such as sculpins (Cottidae) and gobies (Gobiidae) were not counted due to logistical constraints.

Upon the discovery of a lingcod egg mass the following information was recorded: the depth (ft) at which the egg mass was located; location of the egg mass (out in the open, beneath overhanging rocks, within a horizontal or vertical crevice); presence of a guarding male and its total length (cm); volume of the egg mass and the stage of egg development. Egg development stages were described by colour and were classified as creamy (new), white (intermediate), grey-white (old), eyed eggs (almost hatched), and hatched. Underwater dive lights were used to aid in the accurate assessment of the eggs' developmental stages. Egg mass volume (cubic cm) was estimated by measuring the length, width and height (cm) of the egg mass, adjusting for irregularities in shape. The total length of the guarding male was estimated using measuring tape pulled alongside the resting male. A conscious effort was made to lift large flora in search of hidden egg masses.

At the end of each dive, the depth of the cannonball (ft), visibility (m), number of lingcod (guardians and non-guardians) in the quadrat and the sum of all other

counted reef fishes were recorded. Depths were measured in feet with the divers' depth gauges and were later converted to depth in meters. However, they were not converted to below chart datum since the depth at observation best reflects the spawning habitat used by lingcod during the winter. The relief (slope) of the quadrat was estimated as: Flat, <2ft difference in overall depth; Low, 2-7ft difference; High, >8 ft difference less than 45° angle; or Wall, >8ft difference and >45° angle. The type of substrate was estimated using the proportion of the quadrat comprised of three main categories broken down into two or three subcategories: Rock including hardpan, bedrock, boulders; Coarse including cobble, gravel, shell; and Fine including sand and mud. Within these categories an attempt was made to rank the subcategories by dominant habitat feature. Percent complexity of habitat was also estimated as: Simple, smooth with no crevices; Low, <25% of the area contained crevices; Medium, 25-50% crevices; and High, >50% crevices. The type of flora and percent cover that existed in each quadrat was noted as *Agarum* spp. *Nerecystis* spp, *Macrocystis* spp or other.

RESULTS

EGG MASS DENSITY

45 quadrat counts were completed over 8 days between February 19 and March 11, 2005 (Table 1). In the Campbell River area 19 dives were conducted: five at Maud Island, five at Copper Cliffs, five at April Point and four at Discovery passage. Since Snake Island reef has been used as an index site for egg mass density, a total of 19 dives were completed at this site. Seven dives were completed at Entrance Island.

Snake Island reef, Entrance Island and Discovery Passage had the highest egg mass densities of the seven sites surveyed in 2005 (Table 2; Figure 2). Median egg mass densities at Snake Island were lower than previous years (Figure 3). Median egg mass densities at Entrance Island were greater in 2005 than in 2004 (Figure 4). Entrance Island, Discovery passage and Snake Island had the lowest proportion of quadrat counts with no egg masses. The other locations had relatively low or zero median egg mass densities (Table 2) despite the presence of suitable lingcod nesting habitat.

EGG MASS AND GUARDING MALE OBSERVATIONS

35 egg masses were observed in 2005 (Table 3). Egg masses were typically in the later, eyed stage of development, though all stages were observed. The mean estimated egg mass volume was 3664 cm^3. Males ranged in length from 46 to 85 cm. The modal and mean lengths of nest guarding males was 74 cm and 63 cm (n=20) which correspond to sizes at approximately age 5 and 4 years respectively.

REEF FISH COUNTS

Copper rockfish (*Sebastes caurinus*), lingcod, and kelp greenling (*Hexagrammos decagrammus*) were the most consistently encountered fishes (Table 4). Painted greenling (*Oxylebius pictus*), yellowtail rockfish (*S. flavidus*), quillback rockfish (*S. maliger*), juvenile yelloweye rockfish (*S. ruberrimus*), tiger rockfish (*S. nigrocinctus*), striped surf perch (*Emblotoca lateralis*), pile perch (*Rhacochilus vacca*), cabezon (*Scorpaenichthys marmoratus*), whitespotted greenling(*H. stelleri*), and wolf eel (*Anarrhichthys ocellatus*) and were also encountered. Overall, the highest fish densities were observed at Maud Island and Copper Cliffs. The lowest fish densities were observed at April Point and Entrance Island.

DISCUSSION

The egg mass density estimates at Snake Island reef continue the time series for this index site (Figure 3). The egg mass densities, lingcod densities and overall habitat characteristics indicate that April Point and Maude Island may not be suitable sites to revisit for egg mass surveys. Discovery Passage and Copper Cliffs may be useful

to revisit due to high lingcod counts and suitable habitat. Entrance Island had the highest egg mass density and should be considered as a future survey site. Underwater visual estimates of reef fish densities were relatively easy to collect and we feel are likely accurate, given that cryptic fish hiding in crevices can be detected. This survey method may prove to be an informative tool for assessing relative abundance or estimating biomass of reef fishes in shallow waters. We are confident in the data obtained by the volunteer divers in Campbell River and suggest that future programs and surveys attempt to utilize the involvement of the recreational dive community. Improvements to surveys conducted with volunteer divers could include a more random selection of dive sites and method of recording exact quadrat locations.

ACKNOWLEDGEMENTS

Thank you to volunteer divers: Doug Biffard, Bev Biffard, Sandie Hankewich, Mike Kalima and James Dranchuk; as well as Brad Brock with Hang Time Dive Charters. Thanks to Charles Fort and Doug Brouwer for the use of the research vessel and dive equipment during the Nanaimo portion of the survey.

REFERENCES

King, J.R. 2001. Assessment of Lingcod in the Strait of Georgia. Can. Sci. Ad. Sec. Res. Doc. 2001/132. 41 p.

King, J. R., and Beaith, B.W. 2001. Lingcod (*Ophiodon elongatus*) nest density SCUBA survey in the Strait of Georgia, January 16-April 26, 2001. Can. Tech. Rep. Fish. Aquat. Sci. 2374: 21 p.

King, J.R., and Haggarty, D.R. 2004. An examination of recapture rates of lingcod as a potential source of bias in Recreational Catch Per Unit Effort (CPUE) indices. Can. Manuscr. Rep. Fish. Aquat. Sci. 2670: 23 p.

King, J. R., and Winchell, P.M. 2002. Lingcod (*Ophiodon elongatus*) egg mass density SCUBA survey in the Strait of Georgia, January 15-March 13, 2002. Can. Tech. Rep. Fish. Aquat. Sci. 2437: 16 p.

King, J.R., McFarlane, G.A., and Surry, A.M. 2003. Stock assessment framework for Strait of Georgia lingcod. Can. Sci. Ad. Sec. Res. Doc. 2003/062.

Richards, L.J., and Hand, C.M. 1989. Lingcod. pp. 35-61. *In* Groundfish Stock Assessment for the West Coast of Canada in 1988 and Recommended Yield Options for 1989. J. Fargo and A.V. Tyler [eds.]. Can. Tech. Rep. Fish. Aquat. Sci. 1646: 294 p.

Yamanaka, K.L., and Lacko, L.C. 2001. Inshore rockfish (*Sebastes rubberimus, S. maliger, S. caurinus, S. melanops, S. nigrocinctus,* and *S. nebulosus*). Stock Assessment for the West Coast of Canada and Recommendations for Management. Can. Sci. Ad. Sec. Res. Doc. 2001/139.

Yamanaka, K. L., and Richards, L.J. 1995. Lingcod egg mass surveys. pp. 41-51 *In:* M. Stocker and J. Fargo [eds.]. Groundfish Stock Assessments for the west coast of Canada in 1994 and recommended yield options for 1995. Can. Tech. Rep. Fish. Aquat. Sci. 2069: 440 p.

Table 1. Data for dive quadrats including date sampled, site (MI=Maud Island; CC=Copper Cliffs ; DP=Discovery Passage; AP=April Point; SN=Snake Island reef; EN=Entrance Island), the latitude and longitude (in degrees, minutes, seconds) of the buoy marker, quadrat depth (m) as measured by depth gauge at the buoy line, visibility (m) in the water column, the number of lingcod egg masses observed, the number of observed egg masses with guarding males, and the number of males observed in the quadrat that were not guarding a nest. The bottom complexity (smoothness and proportion (%) of area with crevices) and variation in substrate (proportion (%) of area with rock, coarse or fine) of the quadrat was estimated. The relief (flat, low, high or wall) and approximate percent of *Agarum* spp. cover for each quadrat is included.

Date	Site	Quadrat Number	Site	Latitude	Longitude	Quadrat Depth (m)	Visibility (m)	Number of Egg Masses	Number of Guarded Egg Masses	Number of Non-Guarding Males Observed	Complexity (%)				Overall Relief	Substrate (%)			*Agarum spp.* % Cover
											Simple: Smooth No Crevices	Low: <25% Crevices	Medium: 25-50% Crevices	High: >50% Crevices	Flat <2ft Low 2-7 ft High >7ft <45 degrees Wall >45 degrees	Rock: Hardpan Bedrock Boulders	Coarse: Cobble Gravel Shell	Fine: Sand Mud	
02/19/2005	MI	1	MI			44	15	0	0	0		100			High	100			
02/19/2005	MI	2	MI			55	15	0	0	0		100			High	100			
02/19/2005	MI	3	MI	500739.9*	1252024.2*	48	15	0	0	0		100			High	100			
02/19/2005	MI	4	MI			55	15	0	0	0		50	50		High	75	25		
02/19/2005	MI	5	MI			79	15	1	1	1	20	40	40		High	80	20		5
02/19/2005	CC	1	CC			51	15	1	1	1		100			Low	20	80		
02/19/2005	CC	2	CC			47	15	0	0	0		50	50		High	100			
02/19/2005	CC	3	CC	500558.6*	1251618.4*	63	15	0	0	3				100	N/A	n/a			
02/19/2005	CC	4	CC			62	15	0	0	1				100	N/A	100			
02/19/2005	CC	5	CC			26	20	0	0	0			100		High	100			
02/20/2005	DP	1	DP			50	15	0	0	0		40	60		High	80		20	
02/20/2005	DP	2	DP	501136.1*	1252249.1*	50	10	0	0	2			100		High	100			
02/20/2005	DP	3	DP			46	15	1	1	3		80	20		N/A	10	80	10	
02/20/2005	DP	4	DP			52	7	1	1	6	15	30	55		N/A	20	70	10	
02/20/2005	AP	1	AP			38	15	0	0	0			100		Low	90	10		
02/20/2005	AP	2	AP			44	20	0	0	1			100		High	85	15		
02/20/2005	AP	3	AP	500350.4*	1251414.7*	41	20	0	0	0			100		High	100			
02/20/2005	AP	4	AP			33	20	0	0	0			100		High	100			
02/20/2005	AP	5	AP			47	20	0	0	0			100		High	100			
03/03/2005	SN	1	SN	491245.2	1235305.0	44	5	0	0	0		50	50		Low	80	20		20
03/04/2005	SN	2	SN	491243.9	1235303.7	37	9	0	0	1	90	10			Flat	90	10		10
03/04/2005	SN	3	SN	491243.8	1235304.7	30	9	2	1	1	20	80			Flat	80	20		5
03/04/2005	SN	4	SN	491243.4	1235302.7	42	10	1	1	0		50	50		Low	80	20		50
03/04/2005	SN	5	SN	491242.7	1235307.0	41	9	0	0	1		100			Flat	10	90		
03/04/2005	SN	6	SN	491241.8	1235303.1	36	8	0	0	1		50	50		High	50	50		40
03/04/2005	SN	7	SN	491237.9	1235309.2	47	10	0	0	0	30	40	30		Wall	90	10		30
03/04/2005	SN	8	SN	491240.2	1235307.8	33	9	0	0	2	50		50		High	80	20		30
03/07/2005	SN	9	SN	491241.9	1235308.3	40	8	1	1	0		40	60		High	80	20		

* A single position was recorded for the Campbell River sites (MI, CC, DP, AP).

Table 1 continued.

Date	Site	Quadrat Number	Site	Latitude	Longitude	Quadrat Depth (m)	Visibility (m)	Number of Egg Masses	Number of Guarded Egg Masses	Number of Non-Guarding Males Observed	Complexity (%)				Overall Relief	Substrate (%)			*Agarum spp.* % Cover
											Simple: Smooth No Crevices	Low: <25% Crevices	Medium: 25-50% Crevices	High: >50% Crevices	Flat <2ft Low 2-7 ft High >7ft <45 degrees Wall >45 degrees	Rock: Hardpan Bedrock Boulders	Coarse: Cobble Gravel Shell	Fine: Sand Mud	
03/07/2005	SN	10	SN	491244	1235306.5	36	5	3	3	0	10	40	50		Low	80	20		40
03/07/2005	SN	11	SN	491242.5	1235306.8	35	7	0	0	1	15	85			Low	85	15		5
03/07/2005	SN	12	SN	491237.2	1235305.4	30	5	2	2	0	90	10			Flat	100			
03/08/2005	SN	13	SN	491239.2	1235303.0	50	4	0		1	10		20	70	Flat	80	20		100
03/07/2005	SN	14	SN	491235.9	1235307.2	34	8	1	1	1	10	20	70		High	90	10		90
03/08/2005	SN	15	SN	491241.4	1235306.3	25	4	3	3	0	50	30	20		Low	70	30		
03/08/2005	SN	16	SN	491239.9	1235303.8	40	6	0	0	0	60	40			Low	90	10		10
03/08/2005	SN	17	SN	491236.4	1235304.6	40	6	1	1	0	30	70			Low	95	5		75
03/08/2005	SN	18	SN	491237.6	1235308.1	36	6	0	0	0	50	50			Flat	90	10		60
03/08/2005	SN	19	SN	491237.9	1235309.9	50	8	0	0	5	10	40	50		Low	100			10
03/10/2005	EN	20	EN	491236	1234825.9	34	3	2	2	0	70	30			Flat	50	50		0
03/10/2005	EN	21	EN	491237.2	1234829.0	50	4	1	1	0	60	40			Low	60	40		5
03/10/2005	EN	22	EN	491236.5	1234834.0	38	3	0	0	2	15	45	40		Low	95	5		6
03/10/2005	EN	23	EN	491236.3	1234837.6	38	3	3	0	0	50		25	25	High	95	5		0
03/10/2005	EN	24	EN	491238.8	1234842.7	39	4	0	0	0	60	40			Flat	60	40		10
03/10/2005	EN	25	EN	491235.9	1234821.5	31	7	7	7	0			50	50	High	90	10		0
03/10/2005	EN	26	EN	491233	1234824.4	50	7	4	3	1	50			50	High	50		50	60

Table 2. Summary of egg mass densities (egg masses/m²) estimated from the quadrat counts at the six 2005 survey sites.

Site Location	Number of Quadrat Counts	Number of Egg Masses	Density Estimates		Proportion (%) of quadrat counts with no egg masses	Density Estimates (Excluding quadrat counts with no egg masses)	
			Median	Mean		Median	Mean
Snake Island	19	14	0	0.002	58	0.005	0.006
Entrance Island	7	17	0.006	0.008	29	0.010	0.011
Discovery Passage	4	2	0.002	0.002	50	0.003	0.003
Maud Island	5	1	0.001	0	80	0.003	0.003
Copper Cliffs	5	1	0.001	0	80	0.003	0.003
April Point	5	0	0	0	100	0	0

Table 3. Data for each egg mass observed at 2005 site locations (DP=Discovery Passage; MI=Maud Island; CC=Copper Cliffs ;SN=Snake Island reef; EN=Entrance Island). The quadrat that each egg mass was observed in is noted. The depth (m) of the egg mass location, the egg mass dimensions (length, width and height to the nearest cm) and volume (cubic cm) along with the location of the egg mass, the colour of the eggs, the presence of a male guarding one egg mass (M1), guarding two or three egg masses in sequential order (M2 or M3) or an unguarded egg mass (M0), and the total length (cm) of the guarding male are included. If a male was present, but no length is indicated, then measurement was not possible. Boxes are drawn to denote multiple egg masses guarded by a male. If egg mass dimension are not indicated, then the egg mass was located too far underneath a rock or in a crevice to measure. The egg mass location codes include: out in the open=0; under rock=1; in horizontal crevice=2; in vertical crevice=3. Egg development is coded by the following: 1=creamy white (new); 2=white (intermediate); 3=grey white (old); 4=eyed eggs (nearly hatched); 5=hatched.

Site	Quadrat #	Egg mass depth	Egg mass location	Egg colour	Length (cm)	Width (cm)	Height (cm)	Volume (cm^3)	Male Present	Length of Male (cm)
DP	3	50	1	2	12	25	17	5349	M1	50
DP	4	51	1	1	26	15	15	5817	M1	46
MI	5	62	2	1	31	18	27	15149	M1	62
CC	6	46	2	1	40	20	10	8000	M1	63
SN	3	30	1	2,3,4	13	25	7	2275	M2	74
SN	3	30	1	3,4	n/a	n/a	n/a	-	M2	
SN	4	46	0/1	2,5	15	5	8	600	M1	70
SN	9	42	3	2, 4	34	10	13	4420	M1	74
SN	10	40	1	4	42	14	16	9408	M1	64
SN	10	30	2	3, 4	22	8	10	1760	M2	62
SN	10	30	2	4	29	7	8	1624	M2	
SN	11	28	3	3,4	11	10	3	330	M1	46
SN	11	28	2	3,4	36	12	18	7776	M1	57
SN	14	37	1	3	22	11	10	2420	M1	65
SN	15	27	2	4	n/a	n/a	n/a	-	M1	n/a
SN	15	22	1	3	23	8	12	2208	M1	78
SN	15	29	1	2,4	10	9	8	720	M1	56
SN	17	50	2	2,4,5	13	10	23	2990	M1	85
EN	20	31	2	2,4	14	14	21	4116	M2	59
EN	20	31	2	2,4	14	8	17	1904	M2	
EN	21	44	2	2,4	25	10	24	6000	M1	60
EN	23	47	2	2,3,4	13	24	7	2184	M0	
EN	23	48	1	2,3	30	10	8	2400	M0	
EN	23	48	1	2	21	12	9	2268	M0	
EN	25	30	2	4	23	8	6	1104	M3	n/a
EN	25	30	2	4	10	6	18	1080	M3	
EN	25	30	1	4	42	9	23	8694	M3	
EN	25	32	1	4	21	8	14	2352	M2	61
EN	25	32	1	4	23	8	12	2208	M2	
EN	25	30	2	3,4	10	15	25	3750	M1	74
EN	25	34	3	3,4	n/a	n/a	n/a	-	M1	n/a
EN	26	42	1	2,4	13	8	20	2080	M3	63
EN	26	42	1	1	29	10	15	4350	M3	
EN	26	40	1	4	25	6	10	1500	M3	
EN	26	40	3	2,4	9	5	9	405	M0	

Table 4. Fish counts for dive quadrats including date sampled, site location (MI=Maud Island; CC=Copper Cliffs ; DP=Discovery Passage; AP=April Point; SN=Snake Island reef; EN=Entrance Island). Information on latitude and longitude, depth of quadrat (m), visibility (m) and habitat are reported in Table 1.

Date (mm/dd/yyyy)	Site	Quadrat #	Guardian lingcod	Non-guardian lingcod	Kelp greenling male	Kelp greenling female	Copper rockfish	Copper rockfish juv(<15cm)	Quillback rockfish	Quillback rockfish juv(<15cm)	Yellowtail rockfish	Yelloweye rockfish (juv)	Tiger rockfish	Unidentified rockfish (juv)	Painted greenling	Wolf eel	Striped surfperch	Pile perch	Cabezon	Whitespotted greenling	Total # fish
02/19/2005	MI	1					3		5	1									1		10
02/19/2005	MI	2			1	1	3		3								5				13
02/19/2005	MI	3			1	2	4		5								20	20			52
02/19/2005	MI	4					1		6	3											10
02/19/2005	MI	5		2	1		4	1	19	1			3						1		32
02/19/2005	CC	1	1	1	2	1	3	3	6	1											18
02/19/2005	CC	2			3		10	2	10	2			2								29
02/19/2005	CC	3		3			1		18	6			2				1				31
02/19/2005	CC	4		1		1	2		3	1			1								9
02/19/2005	CC	5			3		3		6	2							3				17
02/20/2005	DP	1				1	4	1													6
02/20/2005	DP	2		2	2		3	1													8
02/20/2005	DP	3	1	3		1	3		2	1											11
02/20/2005	DP	4	1	6		3	6			1											17
02/20/2005	AP	1				1			1												2
02/20/2005	AP	2		1	1	4	7														13
02/20/2005	AP	3			3		3		1												7
02/20/2005	AP	4			1																1
02/20/2005	AP	5				1															1
03/03/2005	SN	1			2		4	1	1			1									9
03/04/2005	SN	2		1		1	3														5
03/04/2005	SN	3	1	1	3	1	4	3													13
03/04/2005	SN	4	1			1	11		2						1						16
03/04/2005	SN	5			1																1
03/04/2005	SN	6		1		1	4	1													7
03/04/2005	SN	7						1	3					3							7
03/04/2005	SN	8		2	1	2	4	4	1		1										15
03/07/2005	SN	9	1		1		8	8		1											19
03/07/2005	SN	10	2		1	1	3														7
03/07/2005	SN	11		1		2	2														5
03/07/2005	SN	12	2				3	2													7
03/08/2005	SN	13		1		1	11	2	2	1			1		1	2					22
03/07/2005	SN	14	1	1			5	2													9
03/08/2005	SN	15	3		1		1														5

Table 4 continued.

Date (mm/dd/yyyy)	Site	Quadrat #	Guardian lingcod	Non-guardian lingcod	Kelp greenling male	Kelp greenling female	Copper rockfish	Copper rockfish juv(<15cm)	Quillback rockfish	Quillback rockfish juv(<15cm)	Yellowtail rockfish	Yelloweye rockfish (juv)	Tiger rockfish	Unidentified rockfish (juv)	Painted greenling	Wolf eel	Striped surfperch	Pile perch	Cabezon	Whitespotted greenling	Total # fish
03/08/2005	SN	16					8														8
03/08/2005	SN	17	1		1	1	3	2													8
03/08/2005	SN	18				1	2														3
03/08/2005	SN	19		5	1	1	6	1					1								15
03/10/2005	EN	20	1																		1
03/10/2005	EN	21	1					4													5
03/10/2005	EN	22		2	2	1	7														12
03/10/2005	EN	23			1		8	1													10
03/10/2005	EN	24																			0
03/10/2005	EN	25	4		2		3			1											10
03/10/2005	EN	26	1	1		1	1					1									5
		Total:	22	35	35	31	161	40	94	22	1	2	10	3	2	2	29	20	2	0	511

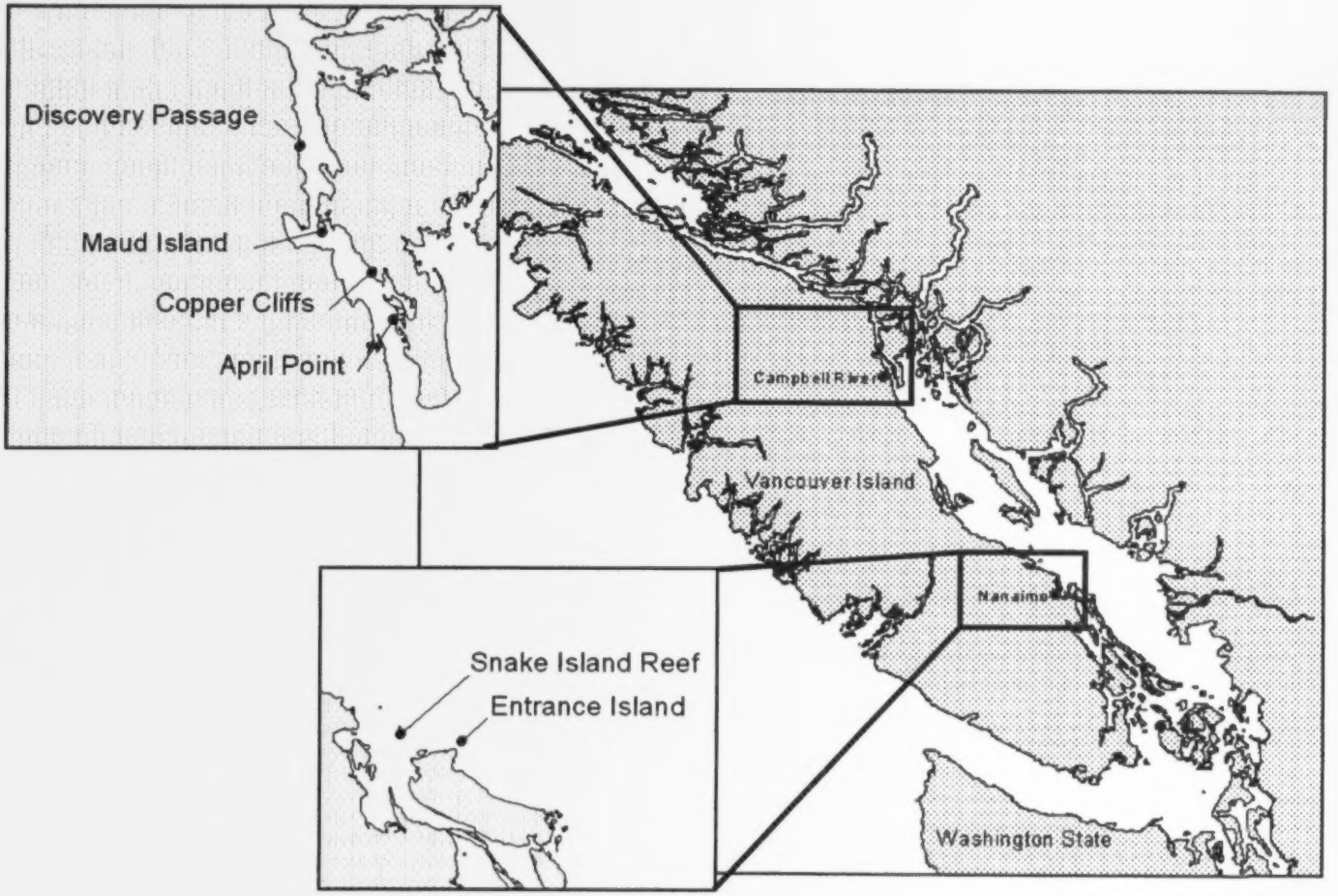

Figure 1. Location of lingcod egg mass and reef fish density scuba survey study areas near Campbell River and Nanaimo on Vancouver Island, February 19-March 11, 2005. Insets illustrate the locations of the six study sites.

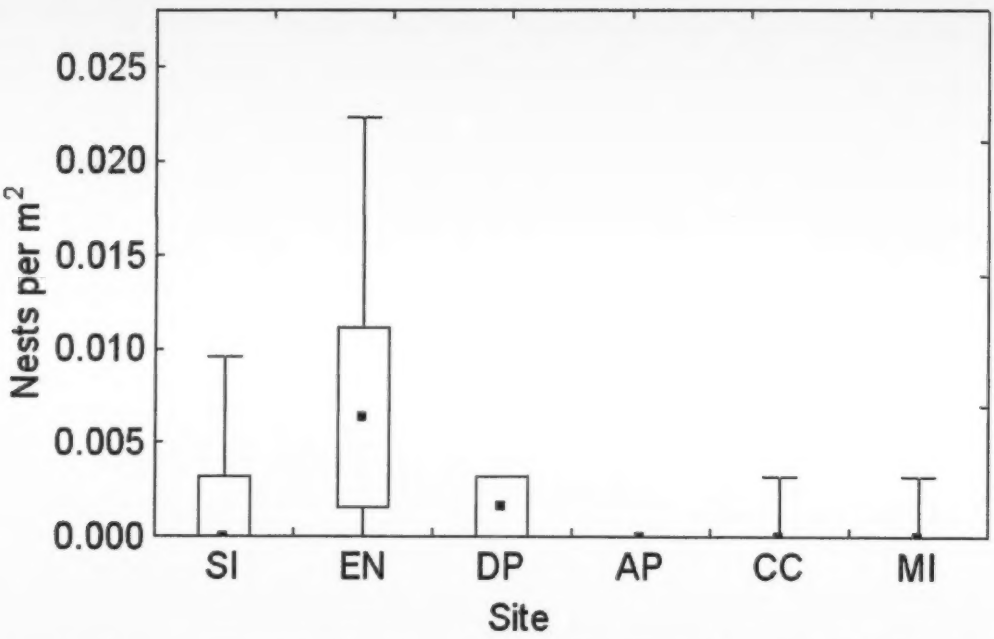

Figure 2. Median egg mass densities for all dive sites surveyed in 2005. (MI=Maud Island; CC=Copper Cliffs ; DP=Discovery Passage; AP=April Point; SN=Snake Island reef; EN=Entrance Island). Whiskers denote maximum and minimum observed egg mass densities; boxes denote 25 and 75 quartiles.

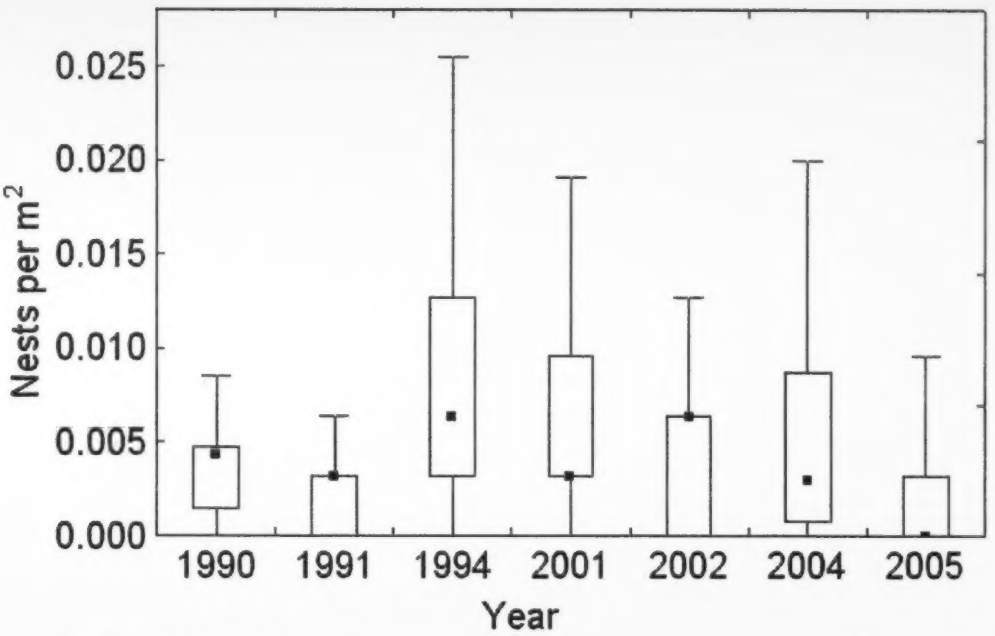

Figure 3. Median egg mass density estimates for each survey year at Snake Island reef. Whiskers denote maximum and minimum observed egg mass densities; boxes denote 25 and 75 quartiles.

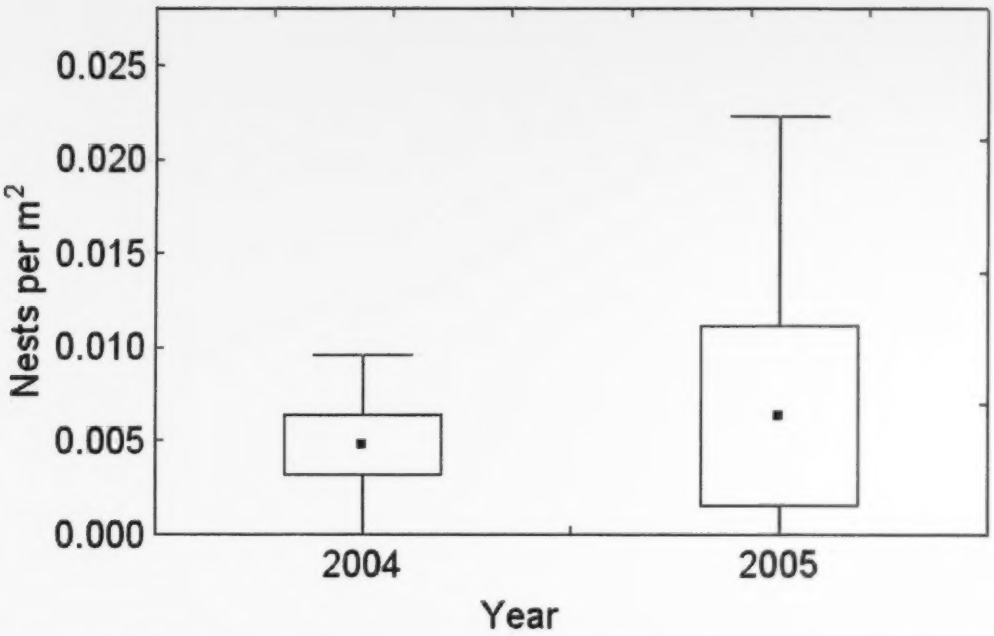

Figure 4. Median egg mass density estimates for each survey year at Entrance Island. Whiskers denote maximum and minimum observed egg mass densities; boxes denote 25 and 75 quartiles.